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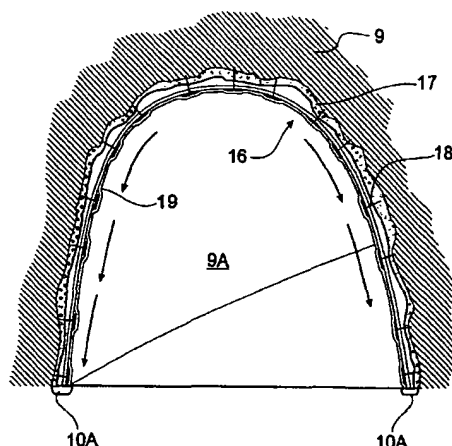
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(54) Title: LINING SYSTEM



(57) Abstract: A method of coating a surface (1C) of a structure (1) with a lining which includes the steps of: (i) application of an internal layer of rigid or flexible material to the surface (1C) which is preferably formed by a plurality of adjacent or overlapping panels (2); and (ii) applying elastomer (3) to the internal layer to provide a durable and protective coating. There is also provided a method of installation of a lining system (10B, 16) to a substrate (9) which includes the steps of: (a) application of an inner layer of pervious material (20, 37A, 40) to the substrate (9) which has one or more hollow passages (21, 31, 43) for directing flow of water away from the substrate (9); and (b) applying an outer coat (22) of elastomer to the inner layer (20) of pervious material.

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# "LINING SYSTEM"

THIS INVENTION relates to a lining system for structures inclusive of tanks, walls including floors and ceilings, pipes, culverts, channels, tunnels, pits, manholes, basins, soffits, aqueducts, mine shafts, roofs and reservoirs. The lining system may be applied to an internal surface of such structures but may also be applied to an external surface thereof if such is considered appropriate.

Conventional sealants for structures may be of several types including bituminous or asphaltic materials as well as filled polymeric emulsions which are related to latex paints. The filled polymeric emulsions have been used as tub caulks and spackling compounds. Principal materials used as sealants include polysulfides, silicones, polyurethanes, acrylics, neoprene, butyl rubber and sulfochlorinated polyethylene. Epoxy resins have been used as *in situ* polymerised plastics in flooring, protective coatings as well as laminates.

Reference also may be made to DE 4344862 which refers to reinforced plastics resin linings for drain and sewage pipes which are hardened *in situ* and attached to an adjacent internal surface by internal pressure directed radially outwards to provide a seamless internal coating or lining.

WO92/15818 refers to lining a pipeline by a radially expanding inner tube which is inserted into the pipeline. The lining has external ribs preventing air from being entrapped between the lining and the internal surface of the existing pipeline.

SU 1689248 refers to an annular membrane held between two sections of a pipeline used for conveying friable material.

GB 2250934 refers to flexible textile tubing formed from a knitted or braided structure thermally protecting fluid circuits which is  
5 lined with cured silicone elastomer.

JP 63294973 describes lining of an underground pipe with a water absorptive resin composition comprising a hydrophilic solvent, inorganic filler and polyacrylic acid salt.

EP 430936 discloses plastics pipe liner which is installed by  
10 curing an inflated uncured plastics coated or impregnated liner.

WO87/05677 refers to a method for lining or over-wrapping conduits which uses helically wound strip to seal a sewer pipe.

WO86/03715 refers to lining material for pipes comprising an airtight tube of woven cloth with a film of synthetic resin on its outer  
15 surface and an inner perforated non-woven tubular fabric impregnated with a binder.

JP 56142031 describes lining an internal surface of a conduit with a tubular lining coating with adhesive.

JP 56049250 refers to linings for dust collectors, pipes and  
20 vessels in flue-gas desulphurisers comprising at least two rubber or plastics layers with an innermost lining containing pin holes to prevent blistering.

US 4228208 refers to lining material for application to internal surfaces of pipes, channels, containers and tanks comprising a

base layer which is covered on one side by a thermoplastic layer and on the other side by an attached layer of fibre pile projecting outwardly therefrom for fixing to a reinforcing material which may be GRP or concrete.

5 DE 2224796 describes a flexible bag of polyarylene for lining beer barrels.

While the above prior art is background prior art concerning linings for pipes, tanks and other structures, it does not deal specifically with the problem of applying elastomer to surfaces that are not  
10 susceptible to satisfactory elastomer adhesion. Such surfaces can be formed from metal, timber, concrete and other settable materials, plastics or composites thereof and may include damp surfaces, uncured surfaces, salt leaching through concrete and surfaces contaminated with oils, acids or fats. In fact, in regard to conventional elastomers, one of the product  
15 specifications or directions for use are that the elastomer should not be used in damp conditions and that an effective vapour barrier (i.e. sealant) must be present for below grade (i.e. below water) or slab-on grade projects. Also, surfaces formed from lightweight concrete, unvented steel pan decks or sandwich slab membranes are not considered suitable for  
20 direct application of elastomer.

The above problem applies particularly in areas of primary containment, i.e. where a protective coating is required to be applied to a surface of a tank or other structure. In areas of secondary containment, i.e. locations adjacent tanks or pipes or valves which facilitate control of

emptying or filling tanks which may contain oil, fuels, acids, caustic soda, solvents or other corrosive or inflammable liquids, generally one particular method of secondary containment is to provide a layer of geotextile fabric on the ground surrounding the tank and also adjacent the  
5 pipes or valves and thereafter apply elastomer to the geotextile fabric.

Another problem with conventional lining systems for tunnels, for example, was that such lining systems were inadequate to prevent or inhibit leakage of water from an internal or external source.

Conventional technology in relation to waterproof lining  
10 systems for tunnels, for example, includes the following steps:-

- (i) initial levelling of the walls of the tunnel by drilling machinery;
- (ii) application for a first layer of sprayed concrete slurry comprising a mixture of sand, finely divided pebbles  
15 or screenings and wet cement, otherwise known as GUNITE, to the levelled walls of the tunnel through a conduit under pressure (e.g. by a pump) from a concrete mixer;
- (iii) insertion of a plurality of support pins into the first  
20 concrete layer wherein each support pin carried on an exposed end an inner plastics disc or "rondelle";
- (iv) applying overlapping sheets of plastics liner or waterproof membrane to the first layer of concrete wherein a wheeled vehicle carrying a scaffold or

support framework was used to carry the plastics sheets whereby overlapping sheets were applied to each inner plastics disc and welded thereto to form a welded joint by a hot air gun or other heat source. To facilitate creation of each of the welded joints, there was often a tamping device or roller applied to each of the joints;

(v) attachment of a plurality of outer plastics discs or rondelles each carrying an eyebolt to each inner plastics disc by welding wherein both the inner and outer plastics disc were separated by the waterproof membrane;

(vi) attachment of reinforcement mesh to each eyebolt; and

(vii) application of an outer layer of sprayed concrete to the waterproof membrane which encapsulated the reinforcement mesh.

In this conventional lining system, it was necessary in relation to each welded joint of the waterproof membrane that there was provided a hollow conduit within each of the welded joints so that air could be pumped into each conduit at a pressure of 2000-2500 psi to check that the joints were air tight.

The conventional lining system as described above was found to be deficient in various aspects which included:-

- 5 (1) there were often air gaps located in the lining system between the waterproof membrane and the inner layer of sprayed concrete within the vicinity of the inner plastics discs which provided passages for water penetration in the event of a water leakage from a source located externally of the tunnel;
- 10 (2) use of the waterproof membrane was disadvantageous if the membrane was punctured during installation of the lining system or subsequent maintenance operations to the lining system;
- (3) the provision of the welded joints provided areas of structural weakness throughout the lining system and thus were prone to leakage if the welded joints lost their structural integrity; and
- 15 (4) the fixing of the waterproof membrane to each of the plastics discs and creation of the welded joints was time consuming and expensive; and
- (5) the provision of fluid conduits within the vicinity of each welded joint also provided potential areas of
- 20 water penetration in the event of water leakage.

It is therefore an object of the invention to provide a method of coating a surface of a structure with elastomer that provides a durable and protective coating.

Another object of the invention is to provide a lining system

for structures or substrates inclusive of tunnels, pits, culverts, channels, mine shafts and reservoirs, that may prevent or inhibit leakage of water from gaining access to the lining system.

In a first aspect of the invention there is provided a method

5 which includes the steps of:-

- (i) applying to a surface of a structure an internal lining of rigid or flexible material which is preferably formed from a plurality of adjacent or overlapping panels; and
- 10 (ii) applying elastomer to the internal lining to provide a durable and protective coating thereto.

In step (i), the panels may be applied to an external surface of the structure or to an internal surface of the structure. The panels may be aligned on the internal or external surface of a continuous side wall of the structure in an edge-to-edge or even overlapping orientation if  
15 desired. Preferably the panels may be bonded to the surface by the use of a suitable adhesive, such as epoxy resin or other adhesive, which will be dependent on the material which constitutes the side wall of the structure. Adhesives may be selected from acrylics, unsaturated  
20 polyesters and other monomer adhesives containing ethylenic unsaturation, epoxy resins, polysulfides, urethanes, silicones and cyanoacrylate adhesives. Alternatively, each of the panels may be fastened to the structure by the use of suitable fasteners inclusive of staples, nails, rivets, screws, bolts or expansion bolts.



Each of the panels are preferably formed from a rigid material inclusive of wood, plastics, steel or other metals inclusive of aluminium. Alternatively, plasterboard or fibreboard may be utilized. Cladding may also be used if desired.

5                   Alternatively, each panel may comprise a plastics sheet formed by injection moulding, compression moulding or rotational moulding which includes an internal space or which is at least partially hollow. Such a material may comprise a plurality of hollow passages which are preferably parallel to each other. An example of such a  
10                   material is that marked under the trade mark KORFLUTE.

                  It is highly desirable, in accordance with the first aspect of the invention, that each internal panel or at least an external surface thereof, be subjected to a preliminary surface modification to improve adhesion of elastomer. In one embodiment, the external surface of each  
15                   internal panel may be subjected to an abrading or rubbing action from a grinder, sander, polisher or other machine capable of providing a roughened surface.

                  In another embodiment, each external surface of each of the internal panels may be shot blasted, sand blasted or provided with a  
20                   surface layer of grit or other small particles which also may facilitate the production of a roughened surface.

                  In another modification, an outer surface of the hollow panel referred to above may be perforated or otherwise modified so that when elastomer is applied to the perforated or modified outer surface "pinlocks"

may be created after application of elastomer as hereinafter described.

In another possible arrangement, an outer surface of a panel formed from any one of the rigid materials described above may be perforated to provide a plurality of recesses or blind holes each suitably having a restricted entrance and enlarged interior to also enable creation of the aforementioned "pinlocks".

In yet another possible arrangement, an outer surface of the panel may be provided with a plurality of projections having an enlarged top or head and a stem of lesser transverse dimension or width. Thus such projections may be complementary in shape to the recesses or blind holes described above.

Elastomer may subsequently be applied to the internal lining and such elastomer may comprise synthetic elastomers comprising polyurea, polyurethane, bituminous compounds, polyvinyl chloride, rubber including synthetic rubber as well as natural rubber and thermoplastic elastomers. Acrylic elastomers, butyl rubber, chlorosulfonate polyethylene, ethylene-propylene rubber, fluorinated elastomers, neoprene, nitrile rubber, polybutadiene, polyethers, polyisoprene, SBRs or polypentenamers may be utilized and especially those that are susceptible for spray on application. However, it will be appreciated that the elastomer may also be applied to the internal lining by brush, roller or other suitable means.

A particularly preferred elastomer is a polyurea elastomer marketed under the trade mark ENVIROLASTIC which is marketed by

EnviroChem Technologies, Forth Worth, Texas, U.S.A. The specification for this material describes it as "based on proprietary urethane polymers and an amine type curing mechanism". It has high strength and high impact and abrasion resistance and is seamless and flexible. It may be applied to concrete, timber or metal substrates.

Other highly preferred elastomers for use in the invention are those that set in a relatively short time period, e.g. 3-45 seconds, such as polyureas or polyurethanes.

In a second aspect of the invention there is provided a lining system which may alleviate the abovementioned disadvantages of conventional lining systems for tunnels such as lining systems installed by the abovementioned "GUNITE" system. In this aspect of the invention there is provided a lining system for installation to a substrate which comprises:

- (i) a first layer of pervious material which directs flow of water away from the substrate; and
- (ii) a second layer of elastomer.

The invention also includes a method of installation of the aforementioned lining system which includes the steps of:-

- (a) applying a layer of pervious material to the substrate; and
- (b) applying elastomer to the layer of pervious material .

Preferably, however, there is applied to the substrate an initial rigid layer of material which may be formed from sprayed concrete

or other settable or rigid material.

Most preferably, however, the initial layer of sprayed concrete is applied to the substrate which may comprise an internal surface or external surface, but more suitably an internal surface of any of the structures referred to above. The initial layer of sprayed concrete may also be applied to a wall, ceiling, floor or roof of a building.

Suitably the sprayed concrete comprises a cement slurry of sand and finely divided particles inclusive of pebbles or screenings. The slurry may be pumped from a concrete mixer or other suitable source to the substrate and applied thereto to obtain a substantially uniform layer of concrete which may be from 20-160 mm in thickness and more suitably 50-100 mm in thickness.

Alternatively, other settable material may be used comprising mortars of other types of cementitious material, bituminous material, fibreglass, polymer activated mortars or a mixture of curing agent or activator and monomer which, after setting, provides a suitable layer or coating of rigid material to the substrate.

In even another situation, the initial layer of rigid material may not be formed from settable material but may include cladding or plastics sheeting.

The initial coating of rigid material is appropriate in some circumstances to provide the substrate with a relatively even or smooth surface so as to facilitate the subsequent attachment of pervious material. This may be suitable where a rock surface may require initial levelling by

a drill or jackhammer to remove rocky outcrops, for example. The initial layer of rigid material then may follow the contours of the substrate.

The pervious material then may be applied directly to the substrate or to the initial coating of rigid material and attached thereto by any suitable method which includes bonding by adhesive or by using  
5 fasteners inclusive of rivets, staples, nails, screws, bolts and the like. Other methods of attachment include heat bond or fusion, chemical bond or encasement of the pervious material.

The pervious material may comprise any material which  
10 allows water to travel from an external source of water adjoining the substrate to suitable drain conduits located adjacent the substrate which therefore direct the flow of leaked water away from a surface of the substrate. Such pervious material may comprise plastics material having a plurality of hollow passages wherein each of the hollow passages are  
15 preferably substantially parallel to each other. Suitably, such plastics material may be formed from injection moulding, compression moulding or rotational moulding. An example of such material is that marketed under the trade mark KORFLUTE.

Another example of pervious material is a layer of particles  
20 or particulate material which comprises beads or particles which may be all embedded or supported in a support surface such as by heating plastics material or elastomer whereby the particulate material may be embedded in the softened material. Water may then be caused to flow in a desired direction by travelling between the particles.

Elastomer may subsequently be applied to the layer of pervious material and such elastomer may comprise any of the elastomers discussed above.

Finally, if desired, in this aspect of the invention, a final coating of rigid material may be applied to the elastomer. This may be any one of the settable materials described previously in relation to the optional initial coating or layer of rigid material and provides the lining system of the invention with a firm support as well as providing a suitable attachment surface for installation of lighting or other equipment. Preferably, the final coating of rigid material will incorporate a sheet of reinforcement mesh and the reinforcement mesh may be attached to suitable suspension means, such as fixing pins, attached to the first layer of rigid material or the substrate *per se*.

It will also be appreciated that the substrate may be formed from any suitable material inclusive of geotextile fabric, timber, steel or other metals, plastics, fibreglass, polystyrene, polypropylene, polyethylene (low density or high density) bituminous material, cementitious material, cardboard, fluted paper product or PVC. Preferably however the substrate is formed from natural rock or earth.

Throughout this specification and claims which follow, unless the context requires otherwise, the word "comprise", and variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers or steps but not the exclusion of any other integer or group of integers.

Reference may now be made to a preferred embodiment of the invention as shown in the accompanying drawings, wherein:-

FIG. 1A is a sectional view of a structure, such as a tank, to which a final coat of elastomer is to be applied using the method of the first aspect of the invention;

FIG. 1B is a perspective view of a panel of an internal lining which is to be applied to the structure of FIG. 1A and to which a preliminary sand blasting operation is being carried out;

FIG. 1C is a similar view to FIG. 1 showing each of the panels being fitted to an internal surface of the structure of FIG. 1;

FIG. 1D is a view showing the application of a final coating of elastomer to the internal lining shown in FIG. 3;

FIG. 1E is a view showing the application of elastomer to a hollow panel which is perforated on an outer surface thereof;

FIG. 1F is a side view of the panel of FIG. 5 applied to a tunnel having an inner layer of sprayed concrete;

FIG. 1G shows a similar view to FIG. 6 showing surface modification of a panel to produce a plurality of recesses or blind holes which produce "pinlocks" after application of elastomer;

FIG. 1H shows a similar view to FIG. 6 showing surface modification of a panel to produce T-shaped outwardly extending projections which also produce "pinlocks" after application of elastomer.

FIG. 2 is a sectional view through a tunnel which has been lined with the conventional "GUNITE" lining system as described above;

FIG. 2A is a detailed view of the roof of the tunnel shown in FIG. 2 showing the lining system in greater clarity;

FIG. 3 is a sectional view through a tunnel which has been lined with a lining system in accordance with the second aspect of the invention;

FIG. 4 is a detailed view of the lining system shown in FIG. 3 showing the lining system in greater clarity;

FIG. 5 is a perspective view showing the application of elastomer to a plastics membrane having internal hollow passages by use of a spray gun;

FIG. 6 is a view of the underside of the membrane of FIG. 5 showing attachment to an inner coating of sprayed concrete;

FIG. 7 is a view similar to FIG. 5 showing another embodiment of the invention;

FIG. 8 is a sectional view through the membrane shown in FIG. 7;

FIG. 9 is a sectional view of an alternative lining system in accordance with the invention;

FIG. 10 is a more detailed sectional view of the lining system shown in FIG. 8;

FIG. 11 is a perspective view of a conventional method of anchoring reinforcement mesh in lining systems shown in FIGS. 2-2A;

FIG. 12 is a method of anchoring reinforcement mesh in accordance with the second aspect of the invention before application of



an outer layer of sprayed concrete;

FIG. 13 is a perspective view of another embodiment of the second aspect of the invention;

FIG. 14 is a perspective view of a variation of the embodiment of FIG. 13;

FIG. 15 is a similar view to FIG. 13 showing another variation of the embodiment of FIG. 13;

FIG. 16 is a similar view to FIG. 14 showing a variation in the arrangement shown in FIG. 14;

FIGS. 17-19 refer to perspective views of manufacture of a lining system in accordance with the invention comprising elastomers with fasteners embedded therein;

FIGS. 20-21 are similar views to FIGS. 17-19 showing variations in the manufacture of the lining system of FIGS. 17-19; and

FIGS. 22-26 refer to the lining system of FIGS. 17-19 or 20-21 being attached to an internal surface of a tank.

In the drawings in FIGS. 1A-1D, there is provided a tank 1 which is used for containing oil, acid, caustic soda or similar corrosive or inflammable liquid. The tank 1 has a continuous side wall 1A and base 1B and an open top 1C to which a cover or lid (not shown) may be applied. There is also shown a panel 2 of rectangular shape to which has been subjected to a sand blasting operation through a gun 2A having operating trigger 2B. This produces a roughened surface 3 to panel 2 as shown in FIG. 1B.

In FIGS. 1C-1D, there are shown panels 2 being attached to internal surface 4 of tank 1 by the use of a suitable adhesive or by the use of appropriate fasteners (not shown). The panels may be attached to internal surface 18 in edge-to-edge or abutting relationship as shown at 2A or by overlapping edge portions (not shown). After the attachment of panels 2 to side wall 1A or of panel 4A to base 1B, elastomer may be applied subsequently to panels 2 as shown in FIG. 1D wherein elastomer 5 is applied to panels 2 and 4A by spray gun 21 to form a durable protective coating.

10 In FIG. 1E, there is provided a panel 6 of plastics material having parallel passages 6A formed by ribs or partitions 6B. In an outer surface 6C of panel 6, there are formed perforations 6D. There is applied to outer surface 6C a coating of elastomer 5 which, when it has set, forms a durable protective coating 5A.

15 In FIG. 1F, the application of elastomer 5 creates "pinlocks" 7 which facilitate the adhesion of elastomer 5 to panel 6. Panel 6 may be attached to a layer 7A of sprayed concrete which is applied to a tunnel 8. Panel 6 may be attached to layer 7A by the use of adhesive 8A or fasteners 8B.

20 In FIG. 1G, in an other modification, panels 8C are provided which may be formed suitably from polystyrene, plasterboard or other rigid material and the like wherein there are initially formed recesses 8D whereby after elastomer 5 is applied to panel 8C, the elastomer may also form "pinlocks" 7 after penetrating into the interior of recesses 8D.

In FIG. 1H, in another modification, panels 8E are provided which have a plurality of T-shaped projections 8F extending outwardly therefrom whereby after elastomer 5A has been applied to panel 8E, there may be formed "pinlocks" 8D after penetrating into areas 8G located  
5 below heads 8G of projections 8F. In this arrangement, set elastomer bounds stems 8H of each projection 8F.

It therefore will be appreciated from the foregoing that the method of the first aspect of the invention, as shown in FIGS. 1A-1H, promotes satisfactory adhesion of elastomer to structures as described  
10 above which provides a durable protective seamless coating. While the aforementioned structures have been described particularly with reference to liquids, it will also be appreciated that the method of the invention may be applied to containers of solids inclusive of fertilizer, pulps and chemicals.

15 In FIGS. 2-2A, the conventional lining system 10 for tunnel 9A located in rock 9, includes a inner coating of sprayed concrete 11 in which have been inserted pins 12 having plastics discs or rondelles 13 to which has been attached a waterproof membrane 14 having joints 15 which have been formed by application of overlapping sheets to rondelles  
20 13 best shown in FIG. 11. This lining system 10 has the disadvantages discussed previously including the possession of air pockets 14A. Tunnel 9 is provided with drainage conduits 10A.

In FIGS. 3-4, there is illustrated the lining system 16 of the invention having an inner coating 17 of sprayed concrete which support

pins 18 to which have been attached plastics discs or rondelles 19 to which has been attached a hollow membrane 20 having internal drainage passages 21 shown in FIGS. 5-6. Membrane 20 is supported or suspended by discs 19 which are then covered by elastomer 22 which is  
5 sprayed onto membrane 20. This process is shown in more detail in FIGS. 5-6 wherein spray gun 23 is shown applying liquid elastomer 22A onto hollow membrane 20 which has been attached to rondelles 19 supported by pins 18. Membrane 20 has hollow drainage passages 21 separated by partitions 24.

10 In another embodiment shown in FIGS. 7-8, the adjacent surface 25 of membrane 20 to elastomer 22 has been provided with apertures or perforations 26 so that when elastomer 22A is applied, part of the elastomer extends or is formed into hollow passages 21 so that there are formed "pin locks" 27 which enhance retention or adhesion of  
15 elastomer 22 to surface 25.

In another embodiment of the invention shown in FIGS. 9 to 10, there is applied an alternative lining system 10B which includes an initial layer of sprayed concrete 17 and thereafter a coating 28 of elastomer is applied thereto. When coating 28 is in a softened state, a  
20 pervious layer 29 of particles or pebbles 30 may be applied to coating 28 so that particles 30 are embedded within coating 28. Subsequently, a final coating 30A of elastomer may be applied to pervious layer 29 so as to securely retain particles 30 in place which thereby provide drainage channels 31 for passage of leaked water when required as shown by the

arrows in full outline.

The embodiment of FIGS. 9 to 10 is useful in that it eliminates any requirement for air pockets 14A which may be present in the FIGS. 1 to 8 embodiment. However, in this latter embodiment, the provision of membrane 20 provides a strong durable membrane which was not susceptible to puncturing as was waterproof membrane 14 used in the prior art. It also will be appreciated that by application of elastomer 22 that a strongly protective and durable seamless or jointless outer skin is applied to membrane 20.

The essence of the second aspect of the invention is therefore, the provision of drainage channels such as channels 21 or 31 in a pervious medium which has been coated with a layer of elastomer 22 or 30A so that water may flow from any location within tunnel 9A to which the lining system has been installed through rock 9 and layer 11 of sprayed concrete when present and down to drainage conduits 10A through channels 21 or 31 as shown by the arrows in full outline in FIG. 3.

Reference may be made to another aspect of the invention which is discussed in FIGS. 11-12 wherein FIG. 11 refers to a conventional lining system as described in FIGS. 2-2A showing a conventional method of attachment or anchoring of reinforcement mesh as described previously and FIG. 12 shows a new method of attachment of reinforcement mesh prior to application of a sprayed concrete outer layer as described previously.

As shown in FIG. 11, there is shown the existing

conventional method of attachment of reinforcement mesh 31 wherein pins 12 are anchored in inner layer 11 of sprayed concrete and which have rondelles 13 attached thereto. There is also shown outer rondelles 13A which result in forming a welded joint 15 between overlapping sheets 32 and 33 of waterproof membrane 14. Pin 12 extends through central aperture 12B of rondelle 13 and also through a corresponding aperture (not shown) of rondelle 13A. Integral with pin 12 is an eye-bolt 34 to which mesh 31 is attached by flexible ties 35. Also shown is an outer layer of sprayed concrete 36. This particular method was time consuming in installation time and relatively complicated.

It therefore will be appreciated that this procedure may be simplified as shown in FIG. 12 wherein pin 12A extends through elastomer 36A forming an enlarged section 37 of elastomer surrounding pin 12A. Eye-bolt 34A which is integral with pin 12A may then be used to mount or anchor mesh 31 by the use of ties 35. Also shown is outer layer 36 of sprayed concrete as well as drainage section 37A which may be provided with channels 21 or 31 as previously described.

There is therefore provided a method of anchoring reinforcement mesh in a lining system in accordance with the second aspect of the invention, which includes the step of having a layer of elastomer applied to a layer of sprayed concrete or other rigid material and wherein the elastomer surrounds an anchoring pin which has a lower end thereof to which the mesh is attached by appropriate fastening means (e.g. clips, ties, C-bolts or U-bolts passing under the reinforcement

mesh) and supporting same prior to application of an outer layer of concrete or other rigid material.

Reference may be made to another embodiment of the invention shown in FIGS. 13-16 wherein there is provided another type of pervious material or material comprising fluid passageways wherein there is provided a layer of mesh having elevated or raised ribs which is attached to a layer of geotextile material to which is then applied elastomer.

In FIG. 13 there is shown mesh 40 comprising a base array of ribs 41 and another array of elevated ribs 42 whereby fluid may travel down passageways 43 shown by the arrows. Any suitable fixing means may be used for the mesh such as mechanical fasteners. In FIG. 13 there is shown an eyebolt 44 embedded in a layer of sprayed concrete 45 to which the mesh 40 is attached by ties 46A. There is also shown a layer of geotextile material 47 wherein mesh 40 is bonded to geotextile material by the use of an adhesive. There may then be applied two layers of elastomer - an inner layer 48 of white elastomer and an outer layer 49 of dark elastomer. The purpose for application of two different colours of elastomer is that if after a period of time layer 49 starts to wear away the other layer 48 becomes visible indicating that the lining system needs repair or that a new lining system may be installed or a new coating of elastomer is required. There is also shown spraygun 50 applying liquid elastomer 51 to the outer layer 49.

FIG. 14 shows eyebolt 44 embedded in a layer 45 of

sprayed concrete wherein the eyebolt 44 supports opposed discs or rondelles 46 which a layer of polymer or plastics lining 52 is sandwiched therebetween. In this drawing it will be appreciated that the mesh 40 and geotextile layer of material may be applied separately.

5                   FIG. 15 shows a similar view to FIG. 13 showing the use of rondelles 46 to support mesh 40 and geotextile layer 47. In this embodiment the layers 48 and 49 of elastomer are applied to the rondelles 46 as shown. There is also shown pins 52 supporting rondelles 46.

10                   FIG. 16 shows a similar view to FIG. 14 showing that geotextile material 47 may be undulating at 54 if desired.

                  From the foregoing it will be appreciated that mesh 40 may be attached to bare rock rather than sprayed concrete and that the provision of drain passages 43 relieves water pressure being applied to  
15                   elastomer layers 48 and 49 as well as diversion of water to drainage conduits.

                  However, it will be appreciated in this embodiment of the invention, the sole purpose of the mesh may be to relieve water pressure rather than diversion of water to drainage conduits.

20                   The mesh 40 is suitably formed from polyethylene or other appropriate plastics material.

                  Reference may be made to another embodiment of the invention shown in FIGS. 17-27 which refers to the sequence of steps that applies to a method of installation of a lining system in accordance with



the invention.

In FIG. 17 a sheet of rigid material, such as plastics sheet 55 formed by high density or low density polyethylene, polycarbonate or timber is subjected to a punching or perforating operation so as to impart  
5 a plurality of apertures 56 which extends through sheet 55. Subsequently a plurality of fasteners 57 are passed through each aperture 56 as shown in FIG. 17. A single fastener 57 is shown in perspective in FIG. 17 and has a head 58 which may be of any suitable configuration but is preferably round and of uniform thickness. There is also provided a  
10 plurality of resilient legs 60 attached to head 58 which in their normal biased position extend outwardly from head 58.

Fasteners 57 may be suitably formed from plastics material and thus may be obtained by any suitable moulding operation such as injection moulding. Head 58 is larger than an associated aperture 56 and  
15 thus has a bearing portion 59 contacting sheet 56.

As shown in FIG. 17 each fastener may be inserted into an associated aperture 56 by inward movement of legs 60 as shown by the arrows in full outline. When the legs 60 have passed through an aperture 56 they are retained within an associated aperture 56 by extension of legs  
20 60 to resume their normal outward bias as shown in FIG. 17. This also means that the underside of head 58 may contact adjacent surface 61 of sheet 55 with bearing portion 59 in contact with surface 61. The insertion of fasteners 57 into their associated apertures 56 may be carried out manually but more preferably this is an automated operation.

Subsequently, as shown in FIG. 18, a coating of elastomer 62 is imparted to surface 61 of sheet 55 preferably by spray gun so that heads 58 are covered by elastomer 62.

After application of elastomer 62, the sheet 55 may then be removed as shown in FIG. 19 by the arrows in solid outline, so as to provide a liner 63 consisting of elastomer 62 and embedded fasteners 57 with legs 60 extending outwardly from liner 63.

Another variation of the method of forming the liner 63 is shown in FIG. 20 wherein there is provided a base sheet 55A similar to perforated sheet 55 with the exception that it is imperforate. A layer of elastomer 62 is then applied to an upper surface of sheet 55a and when elastomer 62 is still in a tacky or non solidified state. A plurality of fasteners 57A having heads 58 and legs 60A are applied to elastomer 62 so that heads 58 are embedded in elastomer 62 and legs 60A extended outwardly therefrom. In this embodiment legs 60A may be rigid as there is no requirement for them to be resilient as in FIG. 17A. It will be appreciated that fasteners 57A may be applied to elastomer layer 62 by a pressing or tamping operation which could be carried out automatically.

Subsequently sheet 55A is removed leaving a liner 63 comprising a layer of elastomer 62 and embedded fasteners 57A with legs 60A projecting outwardly as shown in FIG. 20.

In FIG. 21 it will be appreciated that apertures 56 of sheet 55 do not have to be round and can be rectangular as shown.

Reference is now made to FIGS. 22-27, which illustrate a

method of formation of a tank with liner 63 attached to an internal surface thereof.

In FIG. 22 there is provided a formwork assembly 65 having inner and outer walls 66 and 67 formed of plywood as is shown in the art.

5 In FIG. 23 a liner 63 may be nailed or otherwise fastened to plywood wall 66 by fasteners 69. Subsequently as shown in FIG. 24, sprayed concrete 71 is applied to the gap 70 between walls 66 and 67 and it will be noted that outwardly extending legs 57 or 57A extend into concrete 71 so as to form "pinlocks" in the same manner as shown in FIG. 10 8 to thereby securely attach liner 63 to concrete wall 71.

Subsequently as shown in FIG. 25 plywood forms 66 and 67 are removed providing a final tank structure of concrete wall 71 having liner 63 attached thereto. Finally as shown in FIG. 26 a final coat of elastomer 72 may be applied to internal surface 73 of tank 65 to cover 15 grooves 75 left by overlapping plywood panels (not shown).

An advantage of the embodiment shown in FIGS. 17-26 is the provision of liner 63 which may be supplied to a contractor for lining tanks or other structures formed from settable material which provides a seamless and durable lining which will have a long operational lifetime.

20 Liner 63 is provided in accordance with the first aspect of the invention and it also will be appreciated that liners may also be supplied to contractors as shown in FIG. 1E, FIG. 5 or FIG. 7 for subsequent application to a substrate.

"CLAIMS"

1. A method of coating a surface of a structure with a lining which includes the steps of:
  - (i) application of an internal layer of rigid or flexible material to the surface which is preferably formed by a plurality of adjacent or overlapping panels; and
  - (ii) applying elastomer to the internal layer to provide a durable and protective coating.
2. A method as claimed in claim 1 wherein the panels are bonded to the surface by adhesive.
3. A method as claimed in claim 1 wherein the panels are attached to the structure by fasteners.
4. A method as claimed in claim 1 wherein each of the panels comprise a plurality of hollow passages.
5. A method as claimed in claim 4 wherein each of the hollow passages are parallel to each other.
6. A method as claimed in claim 1 wherein each of the panels are subjected to a preliminary surface modification to improve adhesion of elastomer.
7. A method as claimed in claim 6 wherein the surface modification comprises an abrading or rubbing action to provide a roughened surface.
8. A method as claimed in claim 6 wherein the surface modification comprises application of grit or other small particles to each panel.

9. A method as claimed in claim 4 wherein an outer surface of each panel is provided with a plurality of apertures which communicate with a number of hollow passages whereby after application of elastomer there is provided a plurality of "pinlocks" each having an inner head of elastomer located internally of a stem of restricted dimensions which communicates with an outer coating of elastomer.

10. A method as claimed in claim 4 wherein an outer surface of each panel is provided with a plurality of projections having an outer head and a stem of lesser transverse projections which after application of elastomer facilitate the production of "pinlocks" of elastomer each having a shape complementary to each of the projections.

11. A method of installation of a lining system to a substrate which includes the steps of:

(a) application of an inner layer of pervious material to the substrate which has one or more hollow passages for directing flow of water away from the substrate; and

(b) applying an outer coat of elastomer to the inner layer of pervious material.

12. A method as claimed in claim 11 wherein prior to step (a) there is applied to the substrate an initial rigid layer of sprayed concrete or other settable or rigid material.

13. A method as claimed in claim 11 wherein the pervious material is applied to the substrate by fasteners.

14. A method as claimed in claim 11 wherein the pervious material is applied to the substrate by adhesive.

15.           A method as claimed in claim 11 wherein the pervious material comprises a layer of particles or particulate material embedded in a layer of elastomer whereby hollow passages are created between particles for passage of water.
- 5    16.           A method as claimed in claim 11 wherein a final coating of rigid material is applied to the elastomer.
17.           A method as claimed in claim 16 wherein the rigid material is formed from sprayed concrete or other settable material.
18.           A method as claimed in claim 17 wherein the rigid material  
10 includes a layer of reinforcement mesh.
19.           A method as claimed in claim 18 wherein the reinforcement mesh is attached to an inner layer of settable material by fixing pins.
20.           A method as claimed in claim 11 wherein the pervious material comprises a layer of mesh wherein fluid passageways are  
15 created by the mesh having elevated ribs to which is attached a layer of geotextile material or other rigid or compressible material before application of elastomer.
21.           A method as claimed in claim 11 wherein there are provided an inner layer of elastomer and an outer layer of elastomer each of  
20 different colours.
22.           A method as claimed in claim 20 wherein the layer of mesh is attached to a substrate of bare rock.
23.           A method of applying a liner to a substrate wherein the liner comprises a layer of elastomer having a plurality of fasteners embedded  
25 therein wherein each fastener has one or more outwardly extending legs

which project into the substrate.

24. A method as claimed in claim 23 wherein the substrate comprises a layer of concrete or other settable material.

25. A method as claimed in claim 23 wherein each fastener has  
5 a head and each of the legs are biased outwardly.

26. A method as claimed in claim 23 wherein initially each fastener is attached to a support sheet which is subsequently coated with a layer of elastomer whereby the support sheet is removed to provide said liner.

10 27. A liner for application to a substrate having a layer of elastomer and a plurality of fasteners embedded therein which each have one or more legs extending outwardly from the layer of elastomer.

28. A liner for application to a substrate having a layer of pervious material having one or more flow passages and an elastomer  
15 bonded thereto.

29. A liner as claimed in claim 28 wherein the layer of pervious material is perforated or otherwise surface modified to have elastomer adhering thereto by pinlocks wherein each pinlock has an inner head of elastomer and an intermediate stem of lesser transverse dimension which  
20 extends into the elastomer layer.

DATED this Twenty-fourth Day of July 2000.

WILLIAM CLAUDIO BONA

by his Patent Attorneys

FISHER ADAMS KELLY

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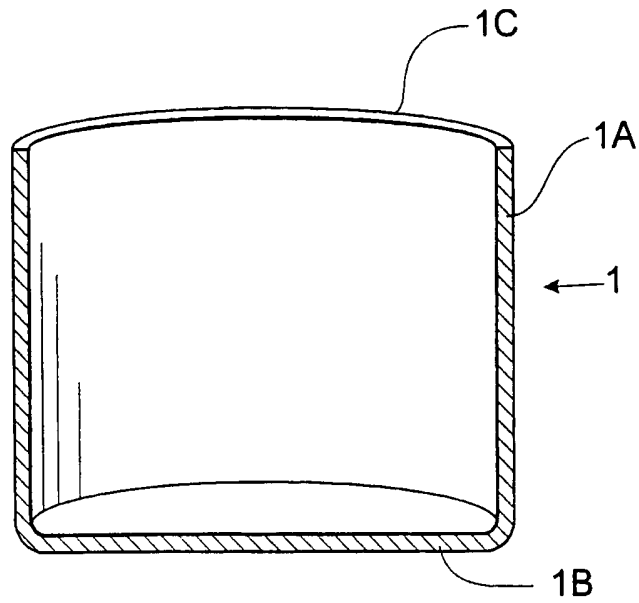


FIG. 1A

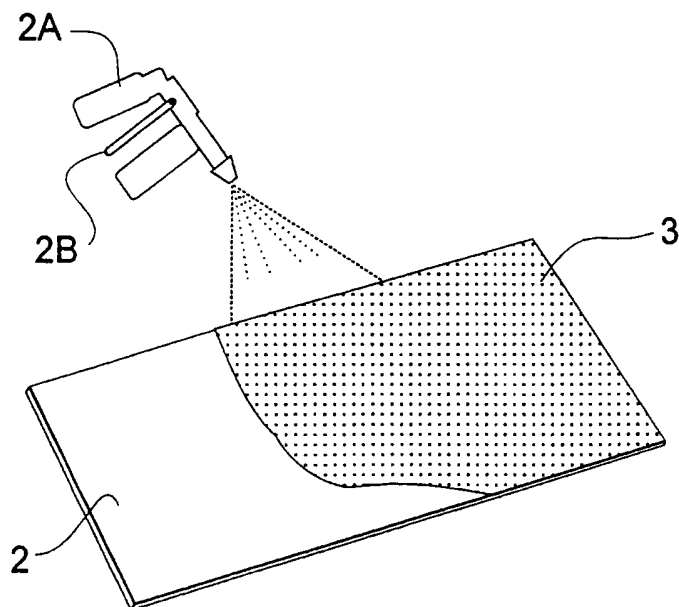


FIG. 1B



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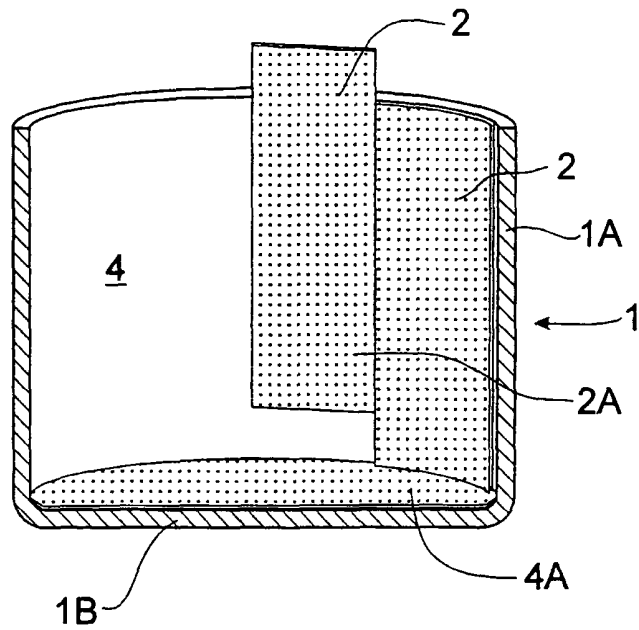


FIG. 1C

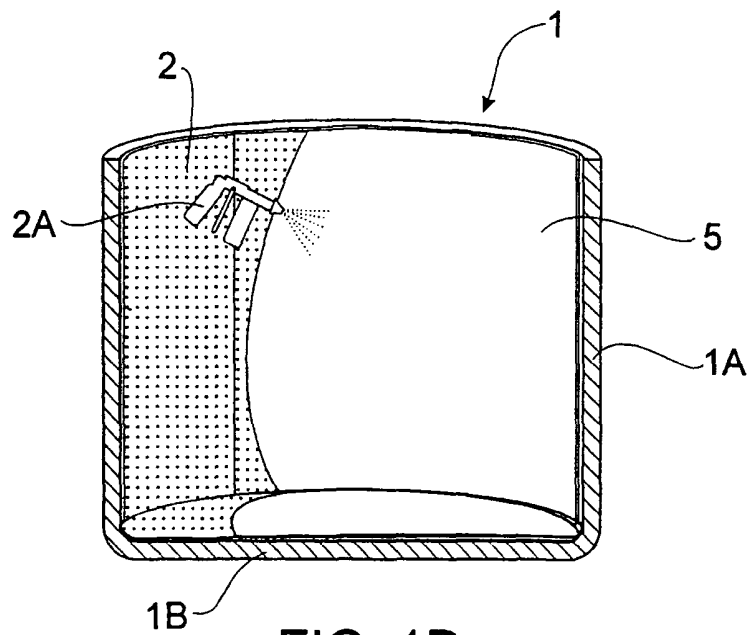
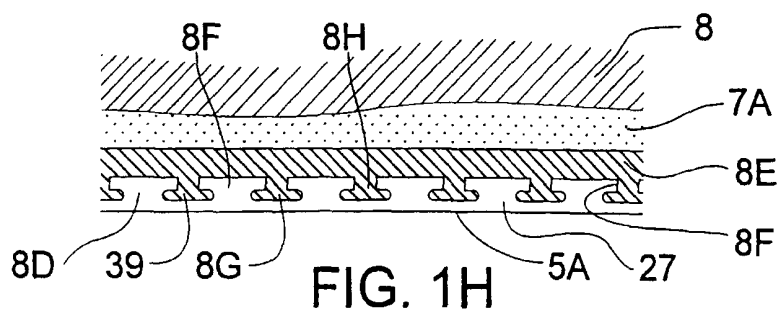
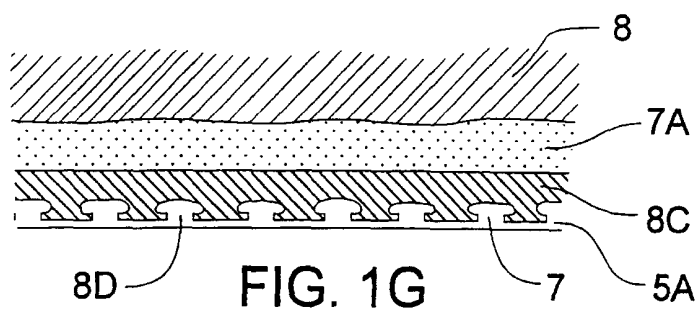
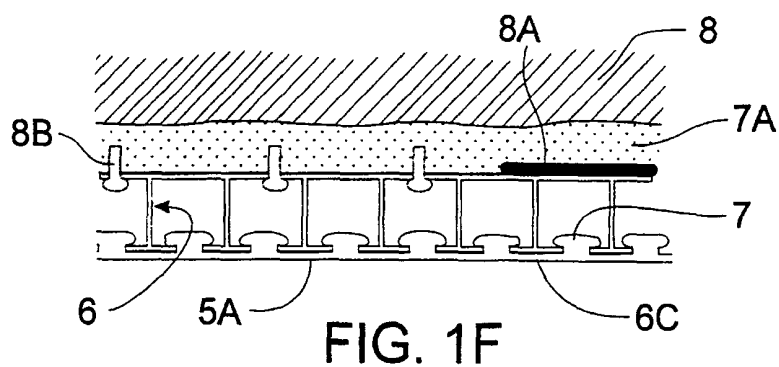
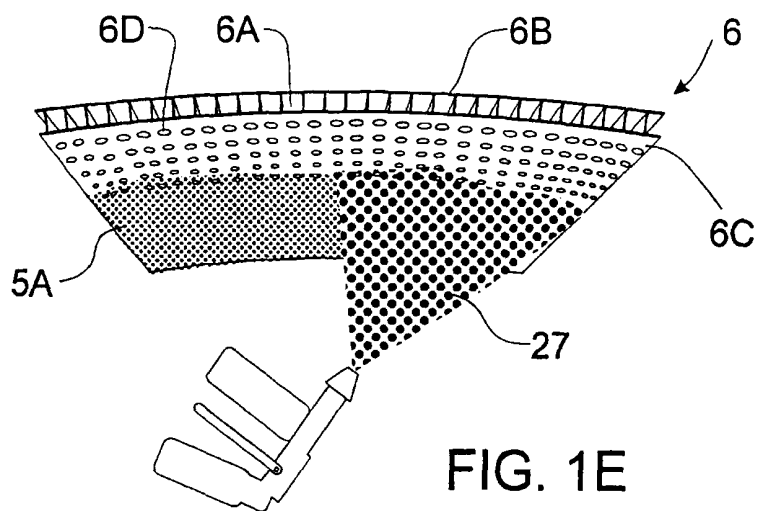


FIG. 1D

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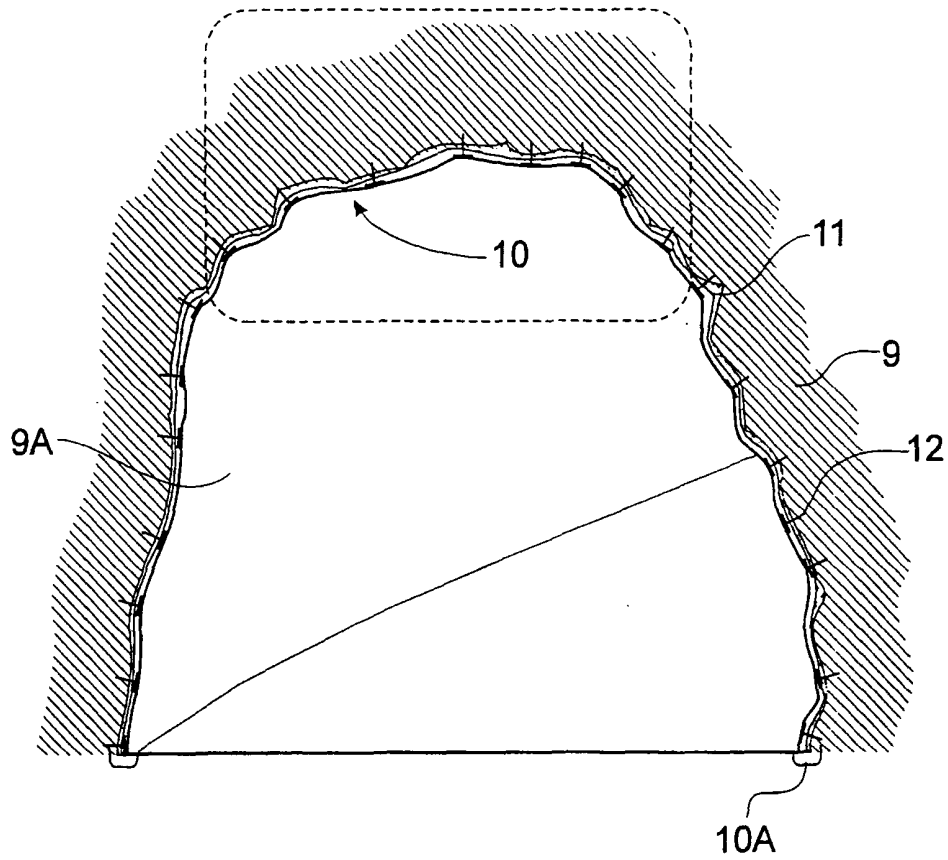


FIG. 2

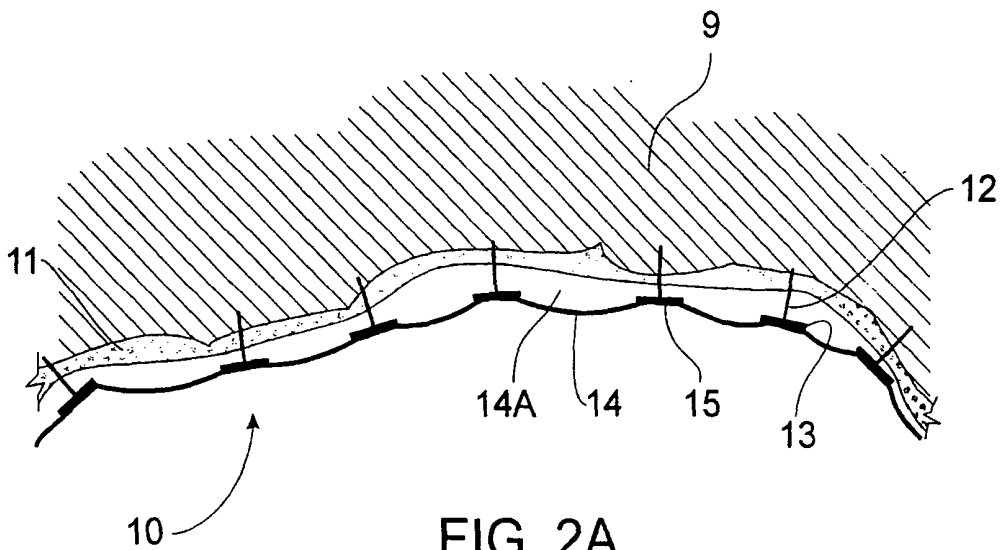


FIG. 2A

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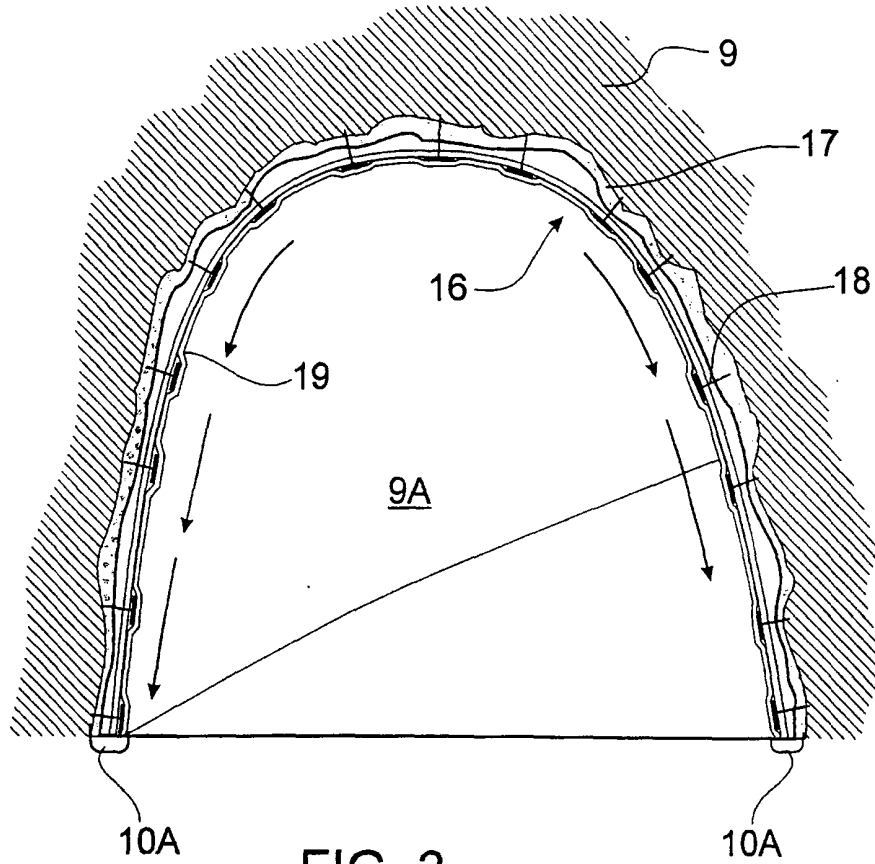


FIG. 3

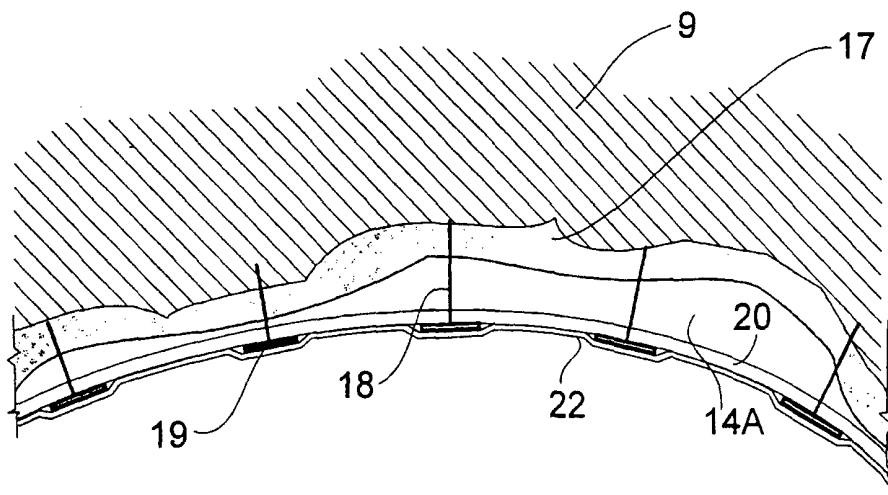
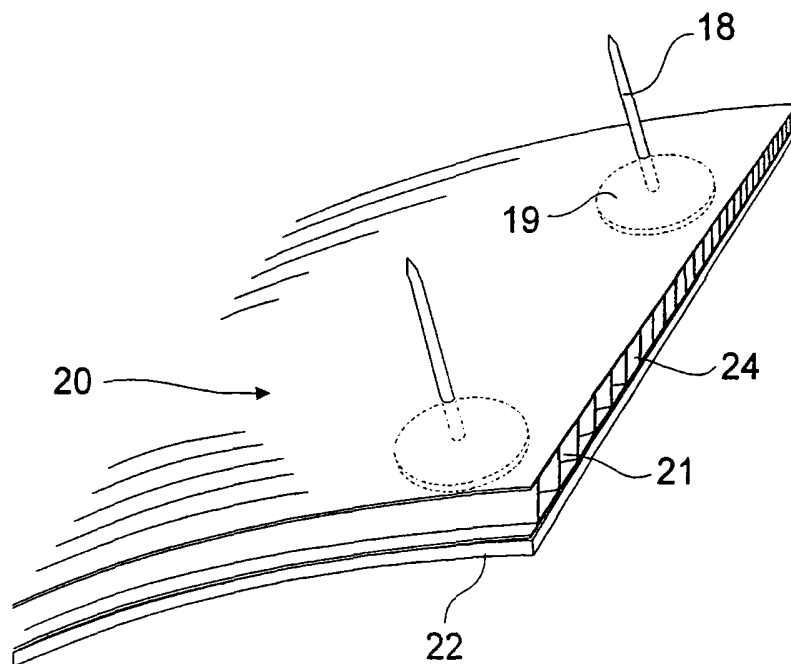
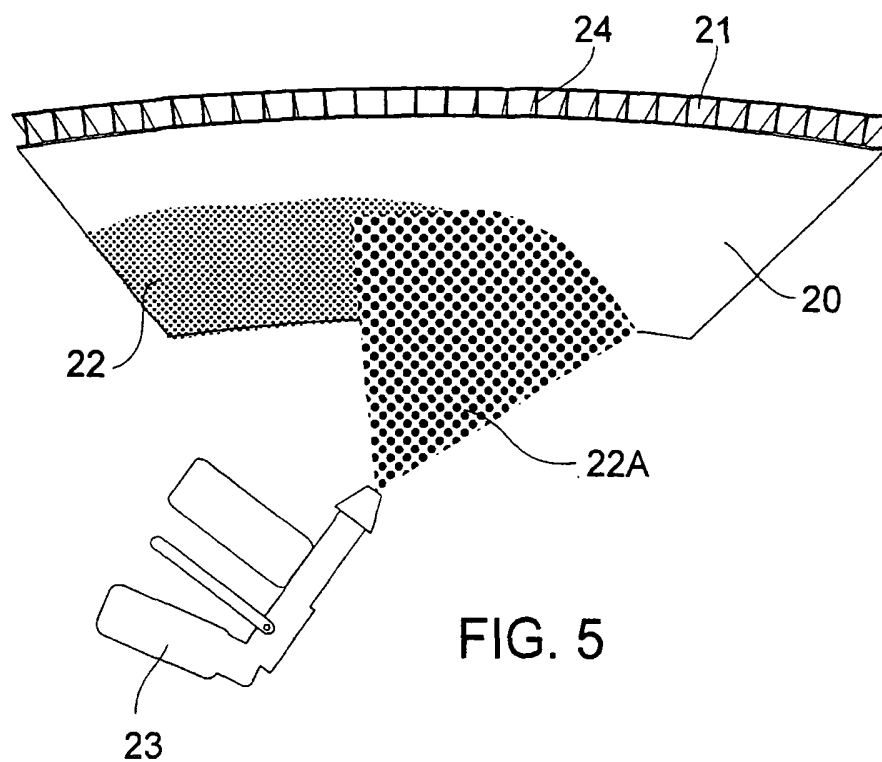
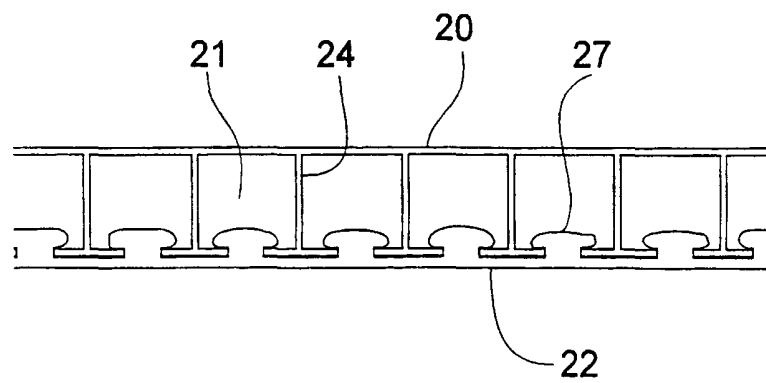
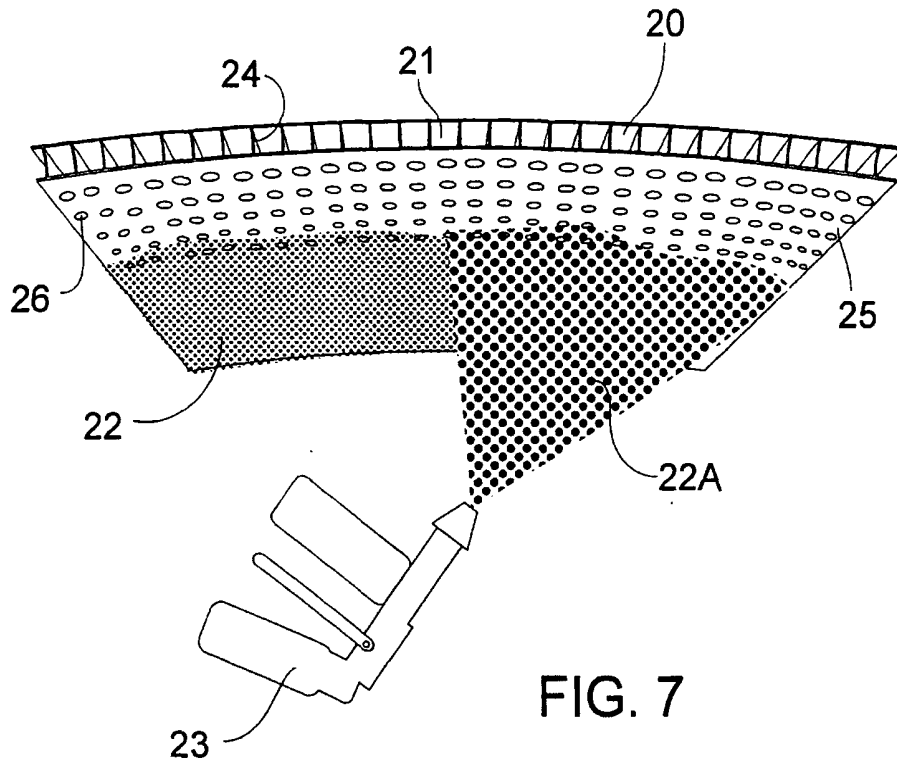


FIG. 4

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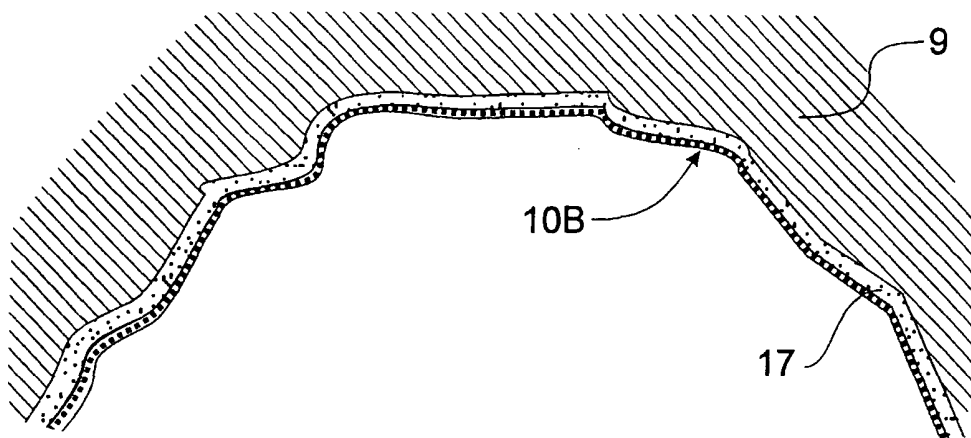


FIG. 9

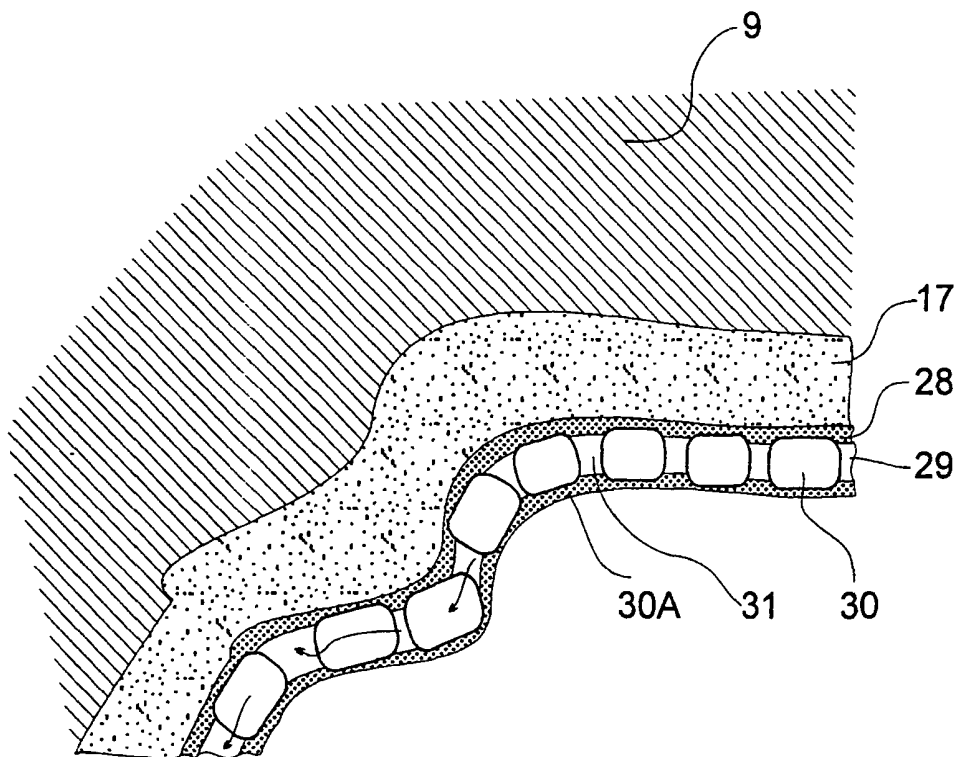


FIG. 10

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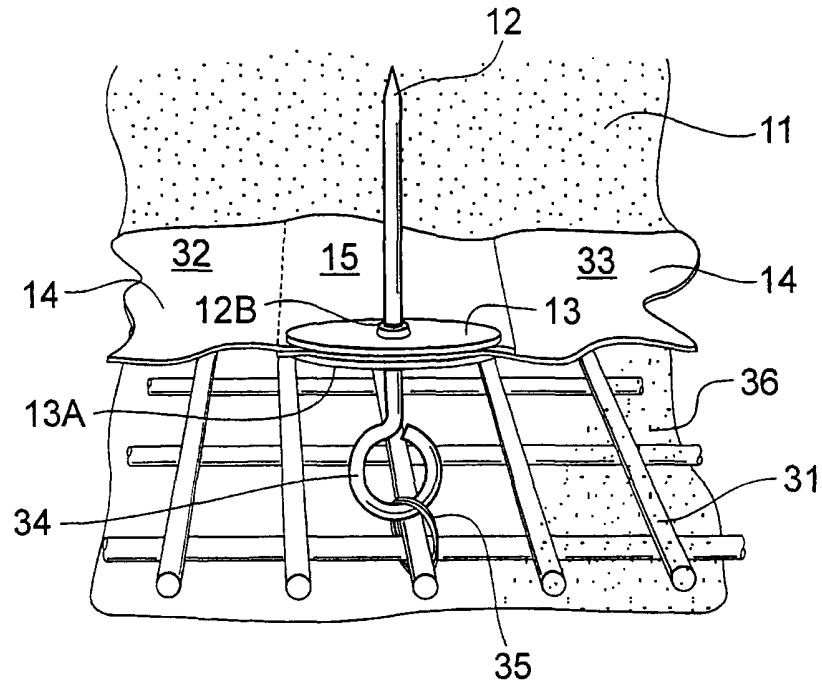


FIG. 11

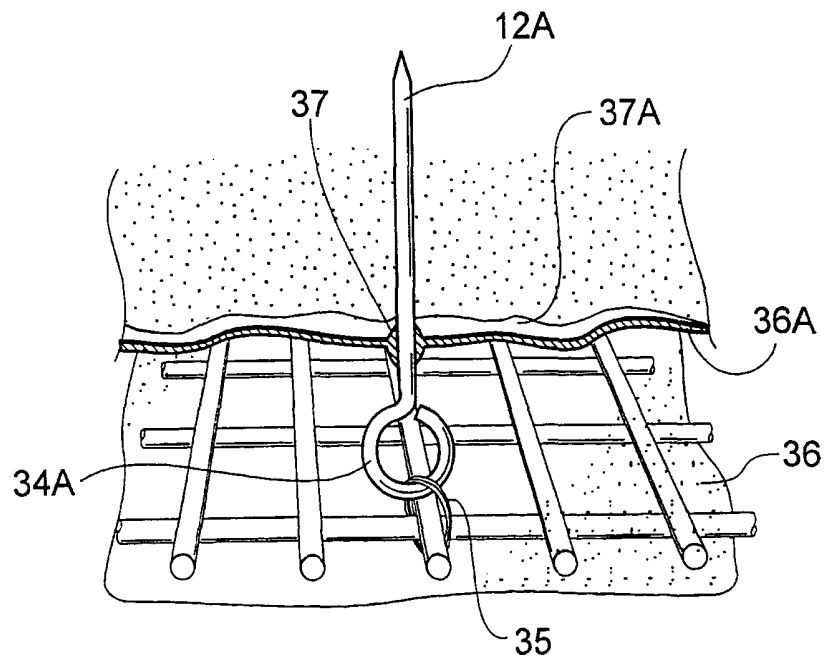


FIG. 12



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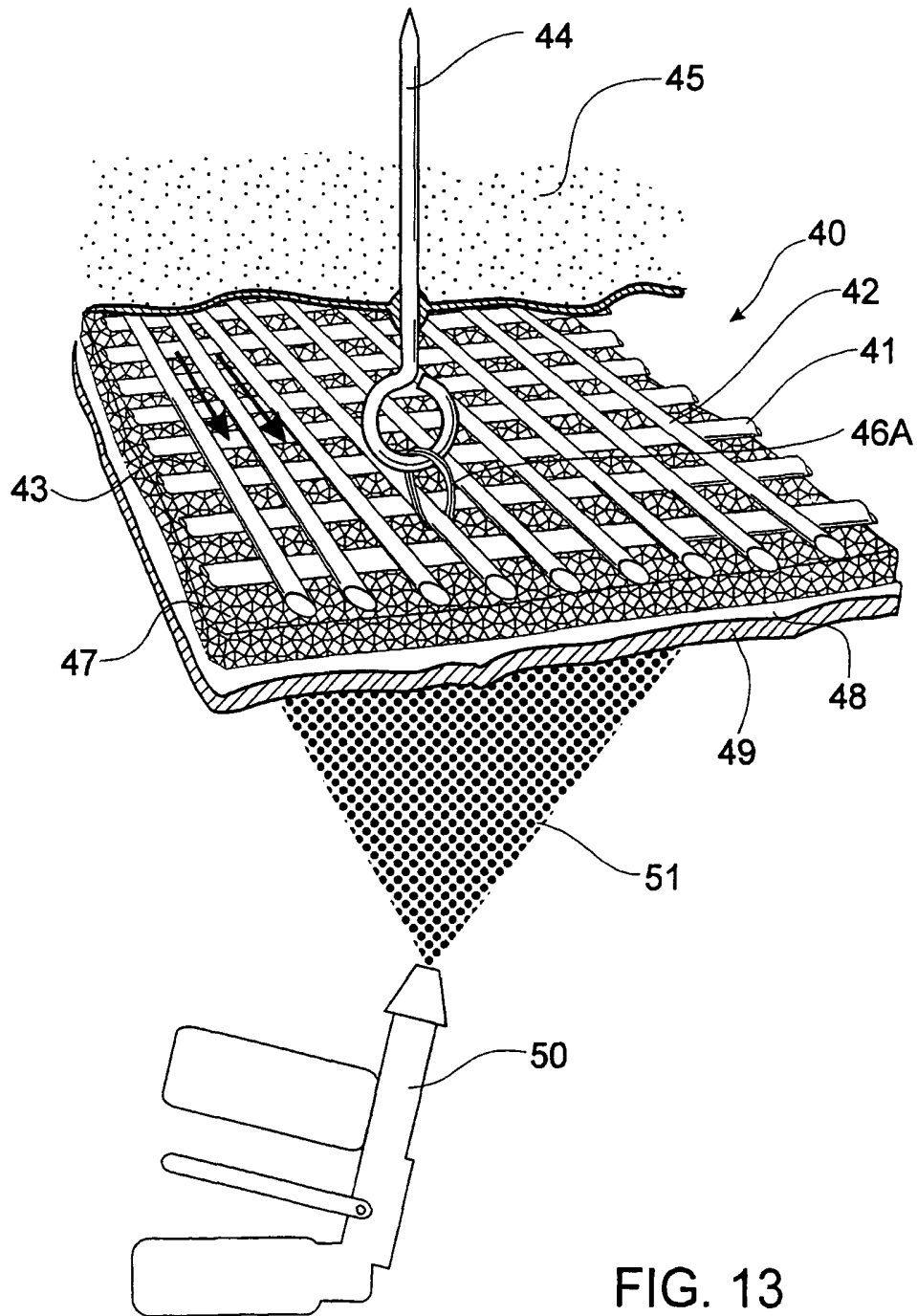


FIG. 13

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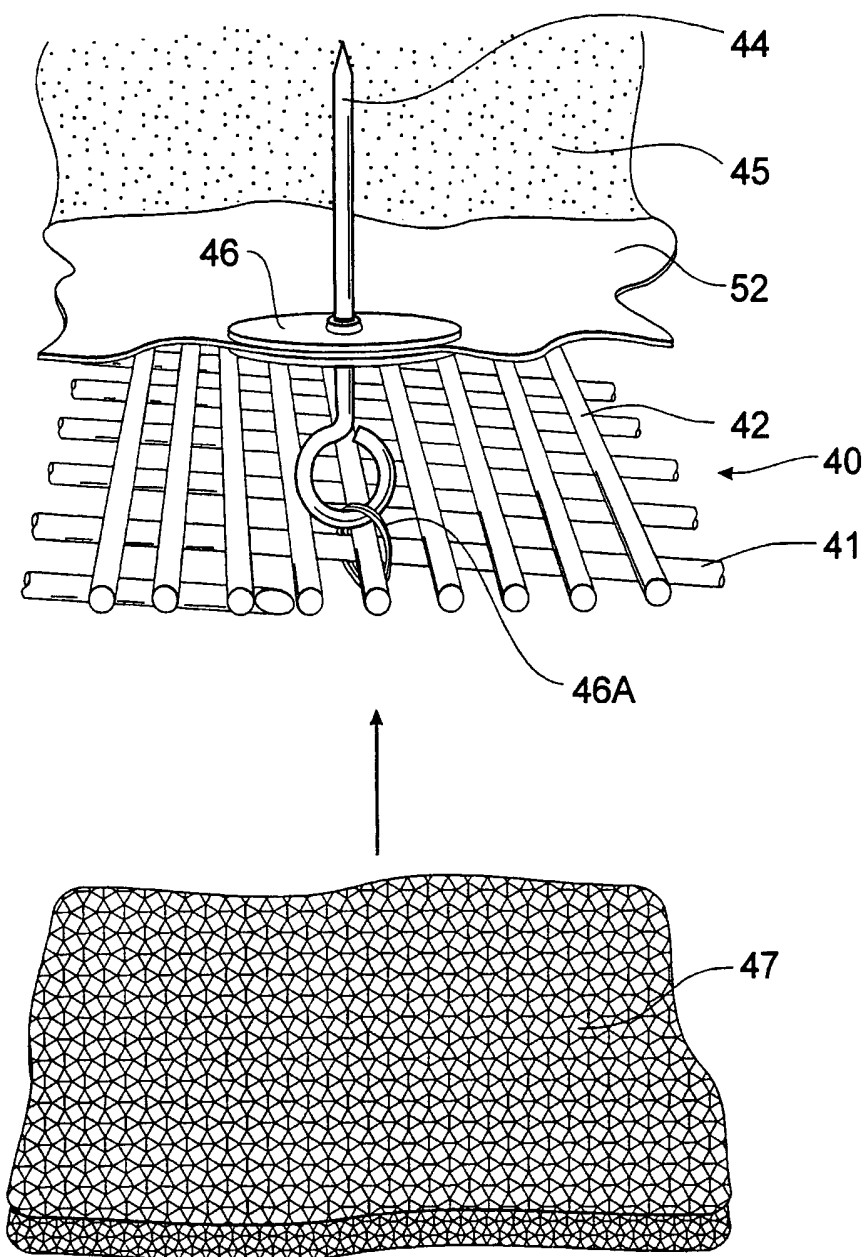


FIG. 14

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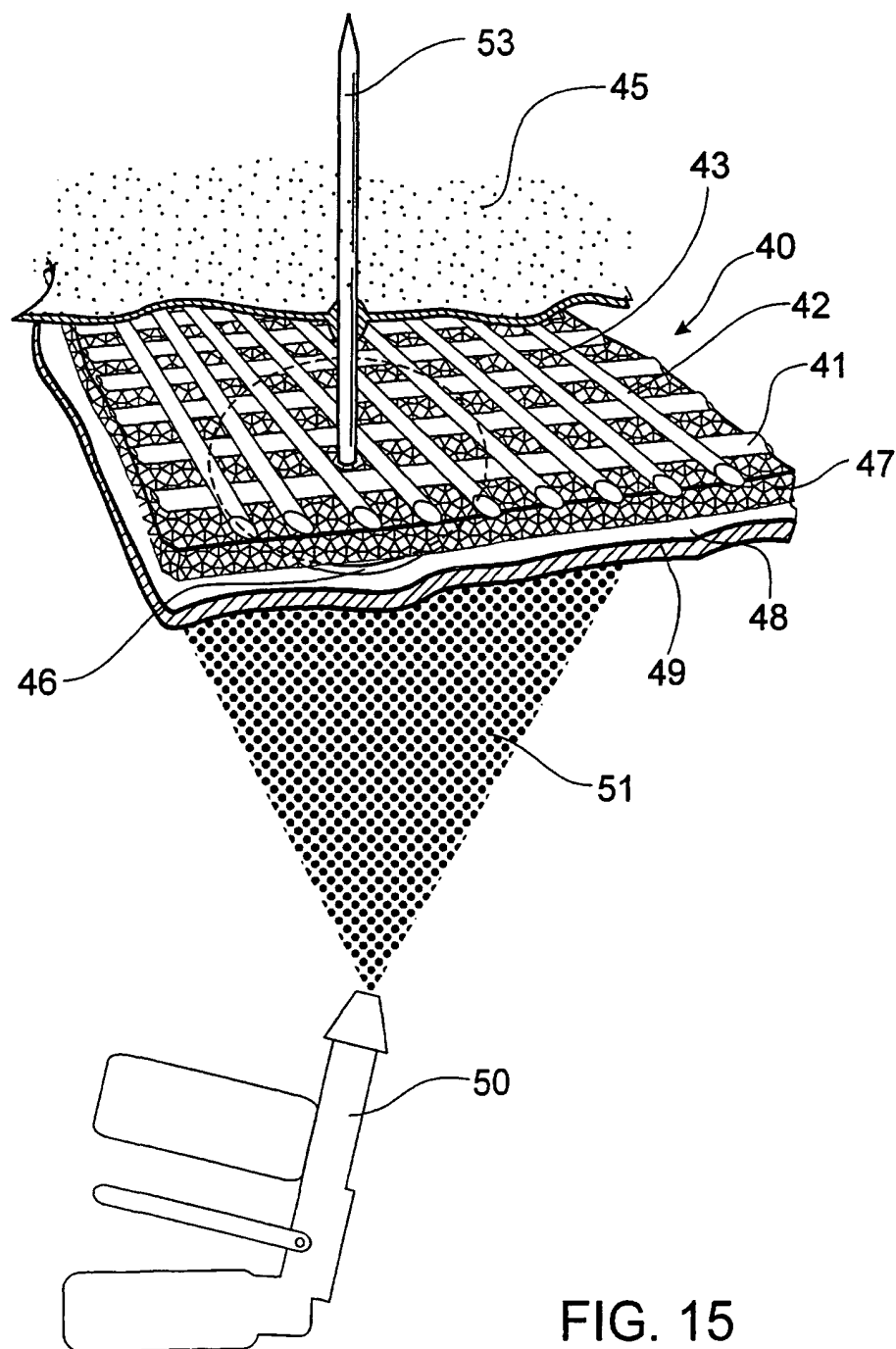


FIG. 15

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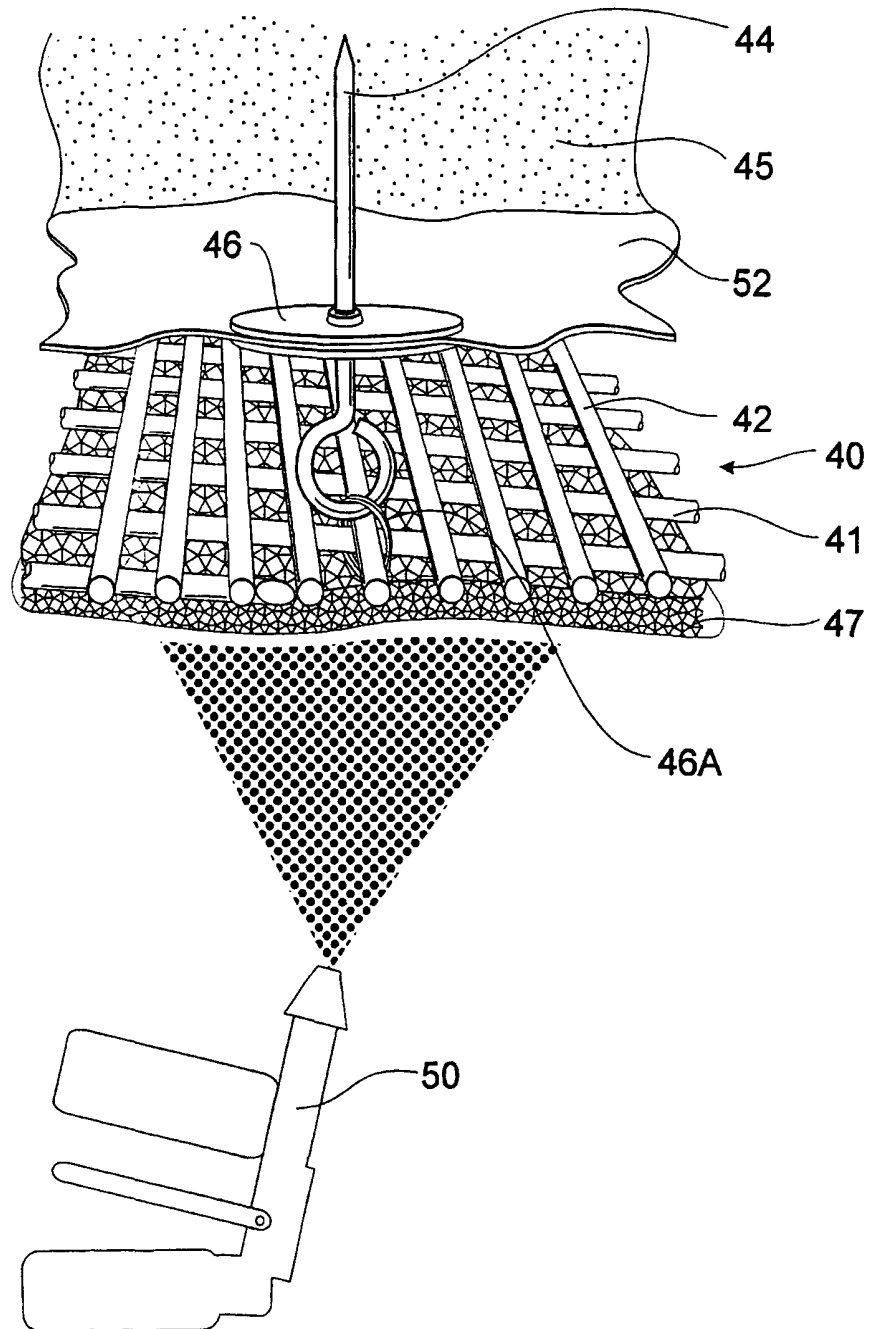


FIG. 16

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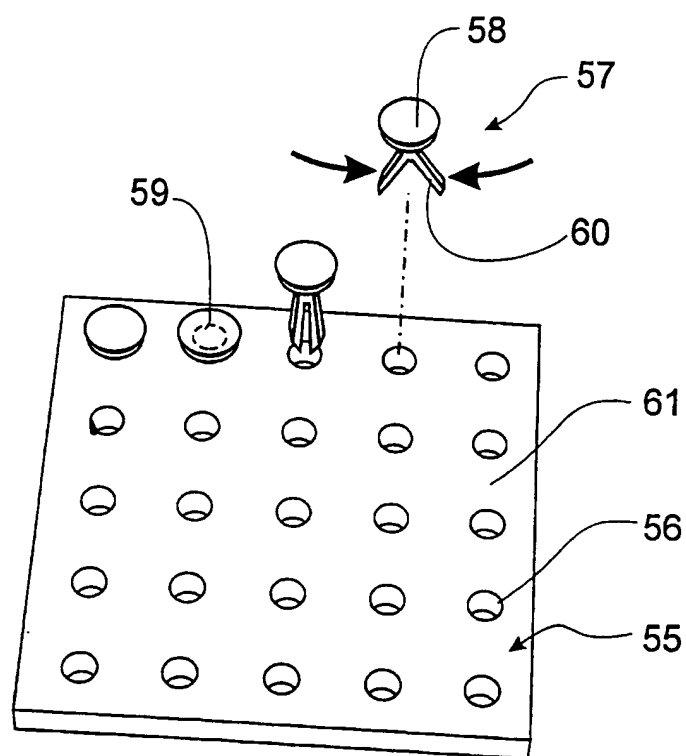


FIG. 17

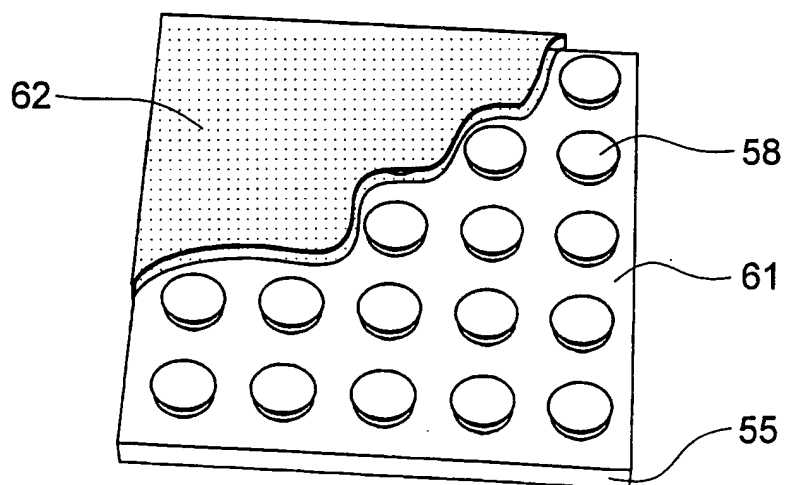


FIG. 18

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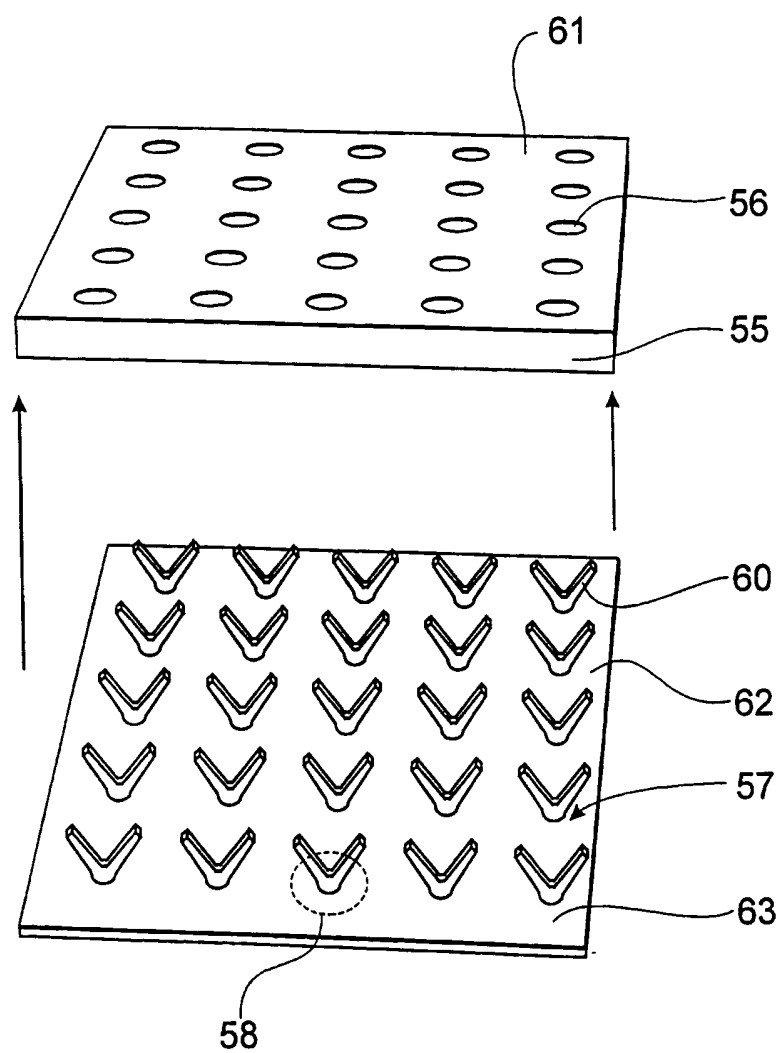


FIG. 19

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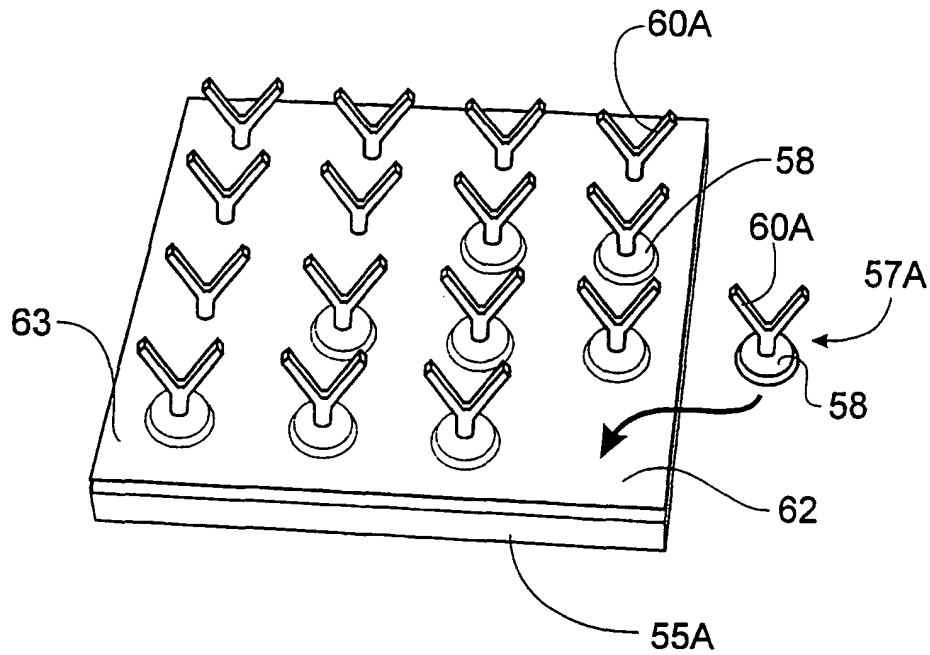


FIG. 20

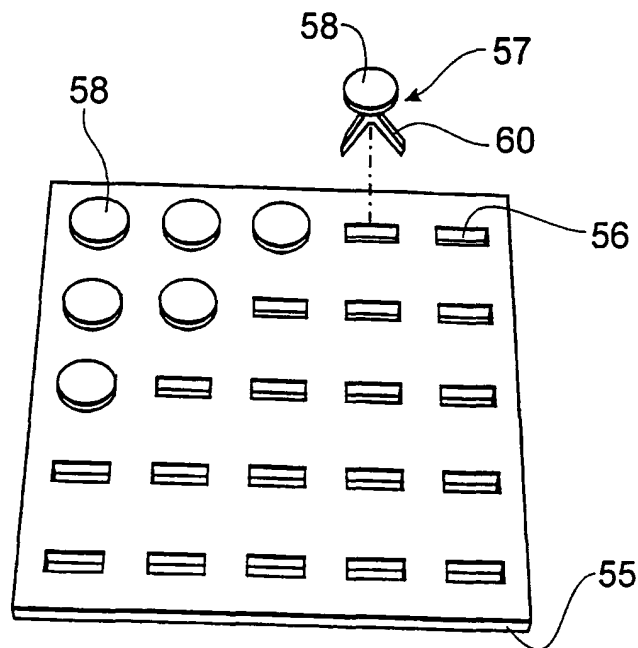


FIG. 21

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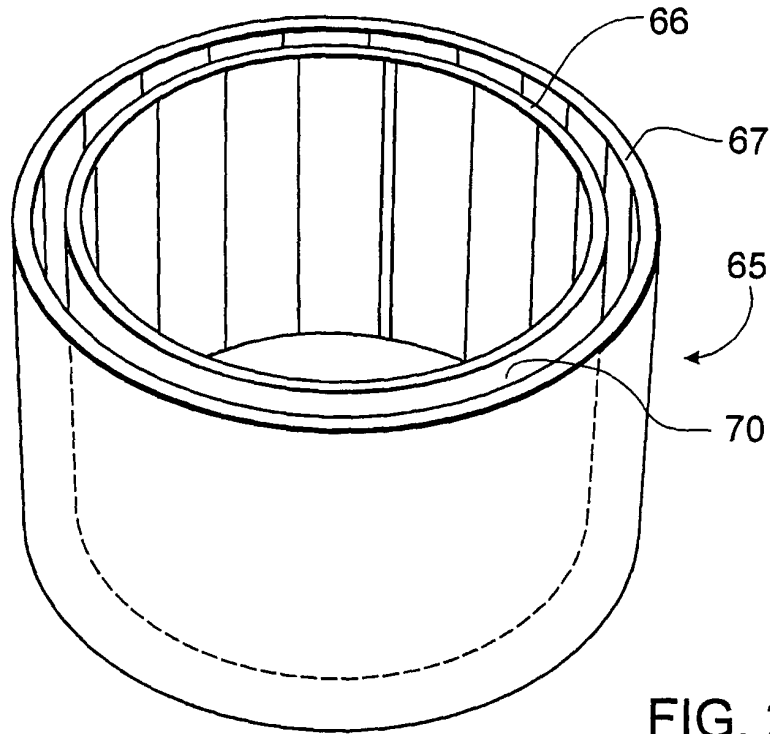


FIG. 22

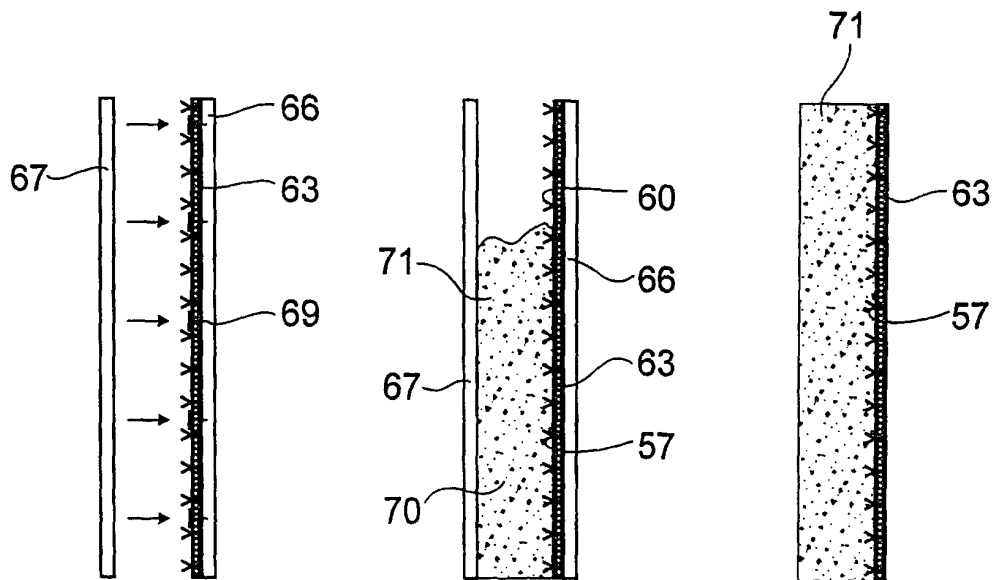


FIG. 23

FIG. 24

FIG. 25



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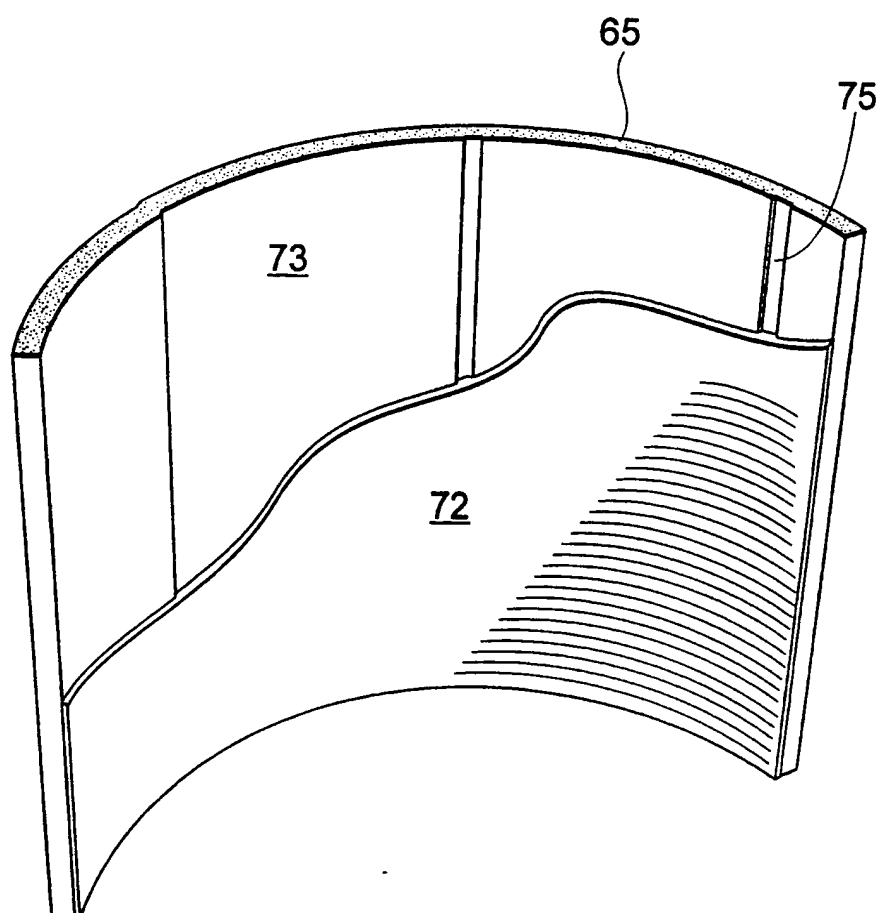


FIG. 26

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU00/00883

<b>A. CLASSIFICATION OF SUBJECT MATTER</b>												
Int. Cl. <sup>7</sup> : E21D 11/00, 11/38												
According to International Patent Classification (IPC) or to both national classification and IPC												
<b>B. FIELDS SEARCHED</b>												
Minimum documentation searched (classification system followed by classification symbols) IPC E21D 11/00, 11/38												
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched AU: IPC as above												
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)												
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>												
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.										
X	DE 1940050 A (SCHWEIZERISCHE ALUMINIUM AG) 19 February 1970 See Derwent Abstract E8767Y/24	1 - 3, 6- 8, 23 - 27										
X	DE 3223330 A (HOLTER) 29 December 1983 Figure 2 and abstract	1 - 8, 11 - 28										
X	AU 70259/87 A (AKESSON) 13 August 1987 Whole document	1 - 8, 11 - 22, 28										
X	US 4439066 A (MCNALLY) 27 March 1984 Figure 3, column 3 lines 6 - 24	1 - 8, 11 - 22, 28										
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C <input checked="" type="checkbox"/> See patent family annex												
<p>* Special categories of cited documents:</p> <table border="0"> <tr> <td>"A" document defining the general state of the art which is not considered to be of particular relevance</td> <td>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</td> </tr> <tr> <td>"E" earlier application or patent but published on or after the international filing date</td> <td>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</td> </tr> <tr> <td>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</td> <td>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</td> </tr> <tr> <td>"O" document referring to an oral disclosure, use, exhibition or other means</td> <td>"&amp;" document member of the same patent family</td> </tr> <tr> <td>"P" document published prior to the international filing date but later than the priority date claimed</td> <td></td> </tr> </table>			"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family	"P" document published prior to the international filing date but later than the priority date claimed	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention											
"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone											
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art											
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family											
"P" document published prior to the international filing date but later than the priority date claimed												
Date of the actual completion of the international search 7 September 2000		Date of mailing of the international search report 13 SEP 2000										
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustalia.gov.au Facsimile No. (02) 6285 3929		Authorized officer  JASON PREMNATH Telephone No : (02) 6283 2127										

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU00/00883

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Derwent Abstract Accession No. 97-116447/11, Class A82 JP 09004393 A (CI KASEI CO LTD) 7 January 1997 Abstract	1 - 3, 6 - 8
X	US 5688580 A (FUKUMOTO) 18 November 1997 Whole document	1 - 3, 6 - 8
P, X	WO 00/05487 A (MBT HOLDINGS) 3 February 2000 Figure 1, page 7 lines 20 - 24	1 - 8, 11 - 28

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU00/00883

**Box I** Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos :  
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos :  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos :  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

**Box II** Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

The international application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept. In coming to this conclusion the International Searching Authority has found that there are three different inventions as follows:

1. Claim 1 relates to a method of applying a liner to a structure by first applying an internal layer and then applying an elastomer to the internal layer.
  2. Claims 11 and 28 are directed to a method of applying a liner or directed to a liner, wherein the liner has a layer of elastomer having a plurality of fasteners (layer of pervious material is not defined)
  3. Claims 22 and 27 are directed to a method of applying a liner or directed to a liner, wherein the liner has a layer of pervious material and an elastomer (fasteners are not defined).
1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims
  2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
  3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
  4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

International application No.  
**PCT/AU00/00883**

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report				Patent Family Member			
DE	1940050	CH	480502	ES	370457	FR	2015641
DE	3223330	NONE					
AU	70259/87	EP	293381	FI	883697	NO	874227
		SE	8600585	WO	8704756		
US	4439066	NONE					
US	5688580	JP	7210593				
WO	00/05487	AU	50286/99	EP	1015734	NO	20001350
END OF ANNEX							

